RESEARCH PAPER | Chemical Science | Volume : 6 | Issue : 1 | JANUARY 2016 | ISSN - 2249-555X

Baker's Yeast: A Green Chemical Method for the Enantioselective Reduction of Carbonyl Compounds

KEYWORDS: Baker's Yeast , Green chemical reduction, Microbial transformation

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ABSTRACT *Green chemical reduction of selected carbonyl compound like 2-acetyl thiophene, 2-acetyl furan will be done by involving microbial transformation. In microbial transformation Baker's Yeast (Saccharomyces cerevisiae) will be used in free form. Use of the whole cell of baker's yeast for reduction of carbonyl compounds is more attractive from economical, environmental and handling points of view. The reduction products will be isolated and purified by chromatographic techniques and characterized on the basis of spectral analysis viz. IR spectral data.*

Introduction

Modern chemistry plays a key role in the improvement of quality of life around the world. However, these advances frequently came with an increase in contamination of the environment by toxic substances. Nowadays steps are being taken, mainly due to increasing economic, social, legal, and environmental pressures, to avoid further degradation. Therefore, the so-called Green Chemical Processes where the "best available technology" not entailing excessive cost and aspiring to "performance without pollution" can be used in industrial processes. The Green Chemistry has emerged since 1990s as away that the skills, knowledge, and talents of chemists can be used through its application to avoid threats to human health and the environment in all types of chemical processes.

A central driving force in this increasing awareness is that it accomplishes both economic and environmental goals simultaneously through the use of sound, fundamental scientific principles. Some of the most active areas of Green Chemistry research and development are application of biocatalyst developments (13-16) in conventional organic synthesis.

Demand for enantiopure chiral compounds (1-12)continues to rise, primarily for use in pharmaceuticals but also in three other sectors: flavor and aroma chemicals, agricultural chemicals and specialty materials. Biotransformation (17-19) has a number of advantages when compared to the corresponding chemical methods. Biocatalysts are known to posses some interesting and advantageous features i.e. high efficiency, mild environmental friendly operation conditions, versatility and last but not least have high selectivity (chemeo, regio, and stereoselectivity). The selectivity and particularly the stereochemical preference are observed when biocatalyst act on their substrates. Besides this economically, some biotrans - formation can be cheaper and more direct than their chemical analogues and the conversion normally proceeds under conditions that are regarded as ecologically acceptable. Because of these reasons the use of enzymes for biotransformation of manmade organic compounds has been used for more than hundred years where in whole cells, organelles or isolated enzymes were employed.

Experimental

In a one litre round bottom flask, equipped with a magnetic stirrer (UTS 2MLH make) 200 ml water, 5 gm fresh BY and 4gm glucose were placed and the suspension for 30 minutes. The dicarbonyl compound was separately dissolved in minimum quantity of absolute alcohol and the ethanolic solution was poured gradually into Baker's Yeast suspension. The resulting solution was magnetically stirred for suitable period. The suspension changes its colour from orange to yellow during the course of reaction.

After the completion of the reaction the resulting mixture was filtered. The water was removed from the solution by distillation. The residue was then extracted repeatedly with diethyl ether. The ether layer was allowed to evaporate. After evaporation product was isolated, purified and characterized by combined application chromatographic techniques and spectroscopy.

Results and discussions:

The actual reducing agent in this system is NADH (Nicotinamide Adenine Dinucleotide Hydride) (20-24). NADH donates hydride (H^-) to aldehydes and ketones and thereby reduces them. The electron lone pair on nitrogen atom of NADH pushes out the hydride ion that is added to a carbonyl group of another molecule to cause its reduction. The process is completed by addition of proton to the carbonyl oxygen. The scheme of the reduction is depicted in the following Fig 1.

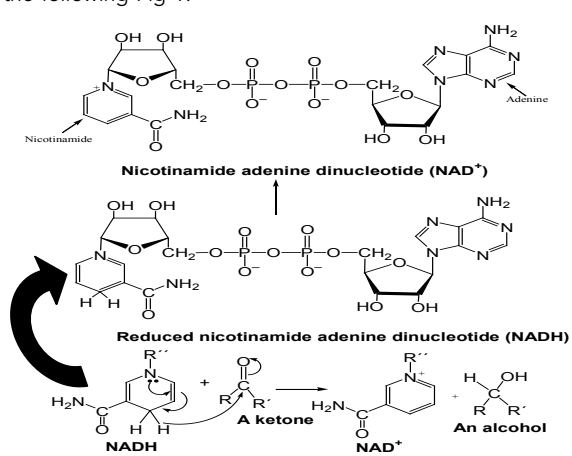

Fig 1. Depicting biological pathway for reduction of carbonyl group by NADH

Volume : 6 | Issue : 1 | JANUARY 2016 | ISSN - 2249-555X

The amount of NADH in the yeast cell is limited to a very low level. In order to allow the reduction continuously, it is therefore, necessary to activate another biological pathway to reduce NAD^+ in to NADH Yeast contains some saccharides in the cell, which reduces, NAD^+ to NADH via pentose phosphate pathway. The addition of glucose to reaction mixture also activates the pentose-phosphate pathway simultaneously feeding the yeast cells while results in an increased concentration of NADH and this ultimately ensure an increase in the enantiomeric excess of the product (25-26).

The characterization of products was carried by IR spectra which were recorded on Bruker ATR Spectrophotometer.

The results of above reductions are summarized in Table 1.

Table: 1 Characterization table for reduction of prochiral carbonyl compounds.

Name of substrate	IR data of product (cm^{-1})	Product Identified
2-acetyl thiophene	3125-3050(C-H stretch) 1590-1400 1390-1350 860-820 700-680 2-substituted bands 3320-3050 (-OH group stretching)	2-{1-hydroxyethane} thiophene
2-acetyl furan	3140-3120(C-H stretch) 1600-1400 770-720 1020-1000 930-910 4-substituted bands 3300-3000 (-OH group stretching)	2-{1-hydroxyethane} furan

Acknowledgment:
Author wish to thank the Head, Department of Pure and Applied Chemistry, University of Kota, Kota for providing the necessary facilities and thanks to University Grant Commission (UGC) , NewDelhi, India for providing Research Start-Up Grant.

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